Primitive Shoshonites from Fiji: Mineralogy, Melt Inclusions and Geochemistry

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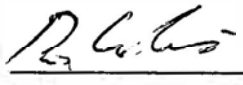

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Abstract

Fundamental issues regarding the origin and evolution of primitive shoshonitic magmas are addressed using mineralogical, melt inclusion and geochemical data from Fijian shoshonites. Melt inclusions in olivine phenocrysts from primitive Fijian shoshonites are used to critically assess the issues relating to melt sampling by high-Fo olivine phenocrysts and address to what degree trapped melt compositions reflect the larger volume magmatic system as a whole.

Shoshonitic magmas erupted in Fiji during the Pliocene (5-3Ma) from 11 main volcanic centres along three broad ENE and NNW trending lineaments. The most mafic shoshonitic lavas (absarokites) range from 8.4-15.2wt% MgO and are highly porphyritic, containing phenocrysts of olivine (to Fo93.2) and clinopyroxene (to Mg# 93.3).

The vast majority of melt inclusions in high-Fo-olivine phenocrysts from Fijian shoshonites have anomalous major element composition, mainly characterised by high CaO contents and high-CaO/Al_2O_3. Anomalous melt inclusion compositions are interpreted to reflect localised, grain-scale dissolution-reaction-mixing processes within the magmatic plumbing system where hot, primitive magma comes in contact with wall-rocks and/or pre-existing semi-solidified mush zones. Injection of hot primitive melt causes partial dissolution of the mush-zone phases, which are not in equilibrium with the primitive melt and mixing of the reaction products with the primitive magma. Rapid cooling at the margins of the magma body induces fast crystallisation and efficient trapping of numerous and large melt inclusions, with anomalous major element composition. Populations of melt inclusions in high-Fo olivine phenocrysts from Fijian shoshonites, and arguably many other subduction-related suites, are naturally biased toward anomalous compositions.

The rare occurrence of normal melt inclusions in high-Fo olivine allows reconstruction of primitive shoshonitic melt compositions. Estimated parental

shoshonitic melts in equilibrium with olivine Fo92.6 have ~16wt% MgO and evolve to compositions ~3-4wt% MgO, via ~63% total crystallisation, involving olivine, Cr-spinel, clinopyroxene, magnetite, plagioclase with minor apatite, phlogopite and/or K-feldspar.

High-Fo olivine phenocrysts (>Fo85) crystallised from primitive shoshonitic melt batches, then resided in cumulate layers within the magmatic system for several months, as inferred from modelling of Fe-loss diffusion profiles surrounding melt inclusions. High-Fo olivine phenocrysts were subsequently entrained from cumulate layers by variably evolved shoshonitic melts during the eruption process. Absarokites with primitive shoshonitic compositions (high MgO contents) consist of variably evolved transporting melts and a cargo of crystals, often derived from different parts of the magmatic system. In most cases the crystal cargo bears no direct relationship to the liquid(s) that entrain and transport them

Fijian shoshonitic suites display a range of enrichment in LILE, Th and P relative to REE and HFSE, reflecting variable contributions by subduction-related components. These components are: a sediment-melt component that, following dehydration of subducted sediment, transfers K, Th, P_2O_5, LREE, some Sr and U to the sub-arc mantle; fluid(s) derived from the dehydration of both subducted oceanic crust and sediment that transfers predominantly Pb, Sr, Ba, K and U; and the sub-arc mantle wedge source component that controls HFSE, HREE, to a lesser degree LREE.

Fijian shoshonites are derived partial melting of the metasomatised, non-convecting upper mantle. Melt production, concentrated at sites of maximum metasomatism in the non-convecting sub-Fijian mantle, focused strain and caused nucleation of lithosphere-scale transtensional or strike-slip shear zones, facilitating rapid rotation of the Fiji Platform between 5-3Ma. Primary shoshonitic melts represent hybrid, vein + wall rock melts, which segregated from upper mantle at ~1.5GPa (~50km depth) with an average melt fraction of ~7% and a temperature of ~1330°C. Advective heating and partial melting of metasomatised sub-arc mantle beneath Fiji occurred in response to a vigorous in-flow of hot asthenosphere following detachment of the stalled Pacific plate at ~12Ma along the Vitiaz trench.

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